

TxBLEND Model Validation for the Upper Guadalupe Estuary Using Recently Updated Inflow Data

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Purpose

This technical memo documents the TxBLEND hydrodynamic and salinity transport simulations conducted for the Guadalupe Estuary at the request of the Guadalupe-San Antonio Bay and Basin Expert Science Team (G-SA BBEST) to aid their effort in fulfilling the mandates of the Senate Bill 3 process for developing environmental flow recommendations for the Guadalupe and Mission-Aransas estuaries. This document focuses on the validation of salinity at sites in the upper Guadalupe Estuary. Additional information about model calibration and performance can be found in the July 2010 report, *TxBLEND Model Calibration and Validation for the Guadalupe and Mission-Aransas Estuaries* (TWDB 2010a), which was presented to a G-SA BBEST Estuary Subcommittee in May 2010.

Background

TWDB staff recently completed a calibration and validation exercise for the Guadalupe and Mission-Aransas estuaries TxBLEND hydrodynamic and salinity transport model (TWDB 2010a). Since that time, new information has become available allowing staff to update and extend the hydrology for the Guadalupe Estuary to include data for gaged and ungaged inflows, diversions, and returns through 2009. Additionally, HDR Engineering, Inc. provided to TWDB their compilation of diversion and return flow data for the Guadalupe and San Antonio River basins for the period 1941-2009. This diversion and return flow data differs from the official record maintained by the TWDB (which includes data obtained from the Texas Commission on Environmental Quality and the South Texas Water Master), but is based on data obtained directly from the permitted diverters and dischargers within the basin (see TWDB 2010b for additional explanation). Therefore, considering the HDR diversion and return flow data to be more complete, the G-SA BBEST requested that TWDB develop an updated hydrology, based on the HDR data, and use this as an input to the TxBLEND model to obtain salinity simulations for use in conducting GIS analyses as part of the effort to determine freshwater inflow recommendations for the estuary. Additionally, the G-SA BBEST requested that TWDB conduct additional validation for sites of interest in

the upper Guadalupe Estuary and in the middle of San Antonio Bay. This technical memo documents the differences in model inputs between the previously reported TxBLEND simulations (*as documented in* TWDB 2010a) and the current simulations being provided to the G-SA BBEST for analysis, as well as the model results and validation of salinity at selected locations within the Guadalupe Estuary.

Model Grid

The full TxBLEND model grid for the Guadalupe and Mission-Aransas estuarine system is presented in TWDB 2010a; however, a close-in view of the Guadalupe Estuary model grid is shown in Figure 1. Within the Guadalupe Estuary, the G-SA BBEST selected ten locations of interest (G1-G10; Figure 2) which correspond to specific TxBLEND nodes within the model grid (Table 1). TWDB conducted additional salinity validation for these locations of interest. Model validation comparisons were made for G1, G2, G3, G4, DELT (near G3), SANT, MOSQ (near G6), and GBRA1 (near G10).

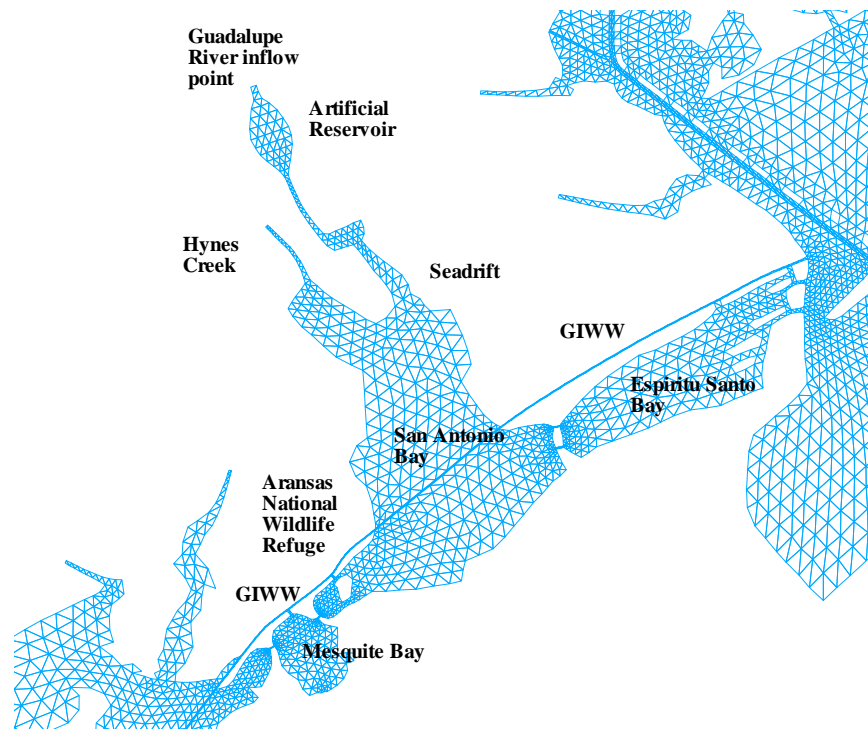


Figure 1. Close-up of the Guadalupe and Mission-Aransas TxBLEND computational grid focusing on the Guadalupe Estuary. The full model grid includes Matagorda, Aransas, Copano, and Corpus Christi bays (see TWDB 2010a).

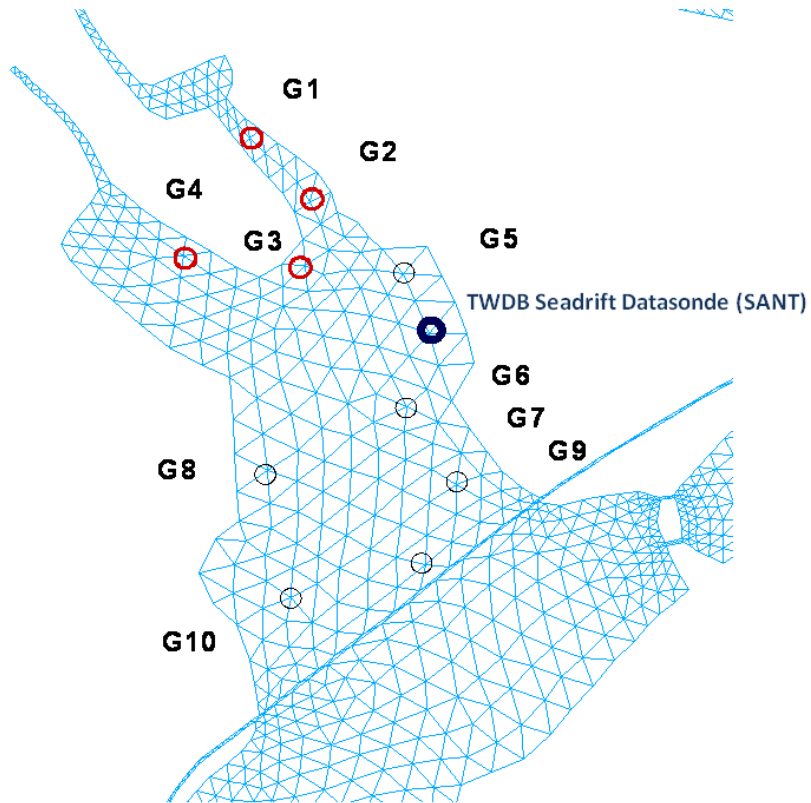


Figure 2. Ten sites (G1 - G10) selected by the G-SA BBEST in San Antonio Bay. Also shown is the TWDB Datasonde station (SANT), near Seadrift. Model validation comparisons were made for G1, G2, G3, G4, DELT (near G3), SANT, MOSQ (near G6), and GBRA1 (near G10).

Table 1. Selected site of interest and corresponding nodes within the TxBLEND model grid.

Site	Description	TxBLEND Grid Node
G1	upper estuary	2773
G2	upper estuary	2612
G3	upper estuary near DELT datasonde station	2570
G4	Hyne's Bay	2687
G5	upper estuary near SANT datasonde station	2347
G6	middle estuary near MOSQ datasonde station	2175
G7	middle estuary	2058
G8	middle estuary	2461
G9	middle estuary	2113
G10	middle estuary near GBRA1 datasonde station	2393

Hydrology

The previous calibration and validation of the Guadalupe-Mission-Aransas TxBLEND model (TWDB 2010a) relied on hydrology version #TWDB201002, which was not fully updated for diversion and return flows through 2009. Additionally, calibration and validation was based on a modified version of the #TWDB201002 hydrology, whereby inflows from four ungaged coastal watersheds surrounding San Antonio Bay (WS24607, WS24608, WS24603, and WS24606; see Figure 5 in TWDB 2010b and Appendix A, Figure A-1) were not included. These watersheds were excluded, because the model has a singular inflow point, the Guadalupe River inflow point. By including the contribution of these watersheds in the Guadalupe River inflow point, model salinity values were too low compared to observed salinity data at the SANT datasonde station near Seadrift (see Figure 2 for SANT location).

Recently, TWDB obtained an independent compilation (prepared by HDR Engineering, Inc.) of diversions and return flows in the Guadalupe and San Antonio river basins below USGS stream gages #8177500 (Coleta Creek near Victoria), #8176500 (Guadalupe River at Victoria), and #81888500 (San Antonio River at Goliad). At the request of the G-SA BBEST, this data was used to develop an alternative hydrology of inflows entering the Guadalupe Estuary (version #HDR201001). Details of this alternative hydrology are reported in the technical memo *Coastal Hydrology for the Guadalupe Estuary: Updated Hydrology with Emphasis on Diversion and Return Flow Data for 2000-2009, November 2010* (TWDB 2010b). For the simulations of TxBLEND considered in this memo, version #HDR201001, including all ungaged watersheds, was used as an input to the model. Figure 3 shows the difference in combined inflows for the modified version #TWDB201002 (Guad2009JM) used in the TxBLEND calibration and validation as compared to the alternative hydrology #HDR201001 used for this technical memo. The largest difference occurs during the 2009 drought, with the newer hydrology showing lower inflows to the estuary. Appendix A also explores in more detail the differences between the two hydrology estimates.

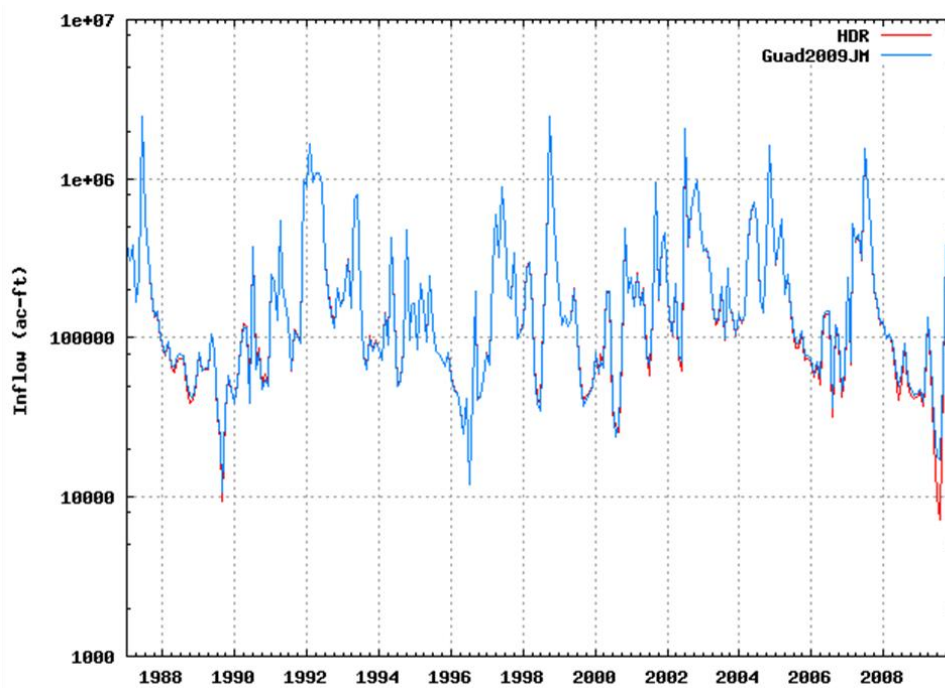


Figure 3. A comparison of estimates of combined inflows to the Guadalupe Estuary for the modified hydrology version #TWDB201002 (Guad2009JM, blue) and the alternative hydrology version #HDR201001 (red); ordinate is a log scale.

Salinity Data

TxBLEND model calibration and validation require salinity data. While time-series salinity data is preferred due to increased reliability for model comparisons, it is not often available at more than a few select locations within the estuary (Figure 4). Alternatively, numerous point-measurement data are available from monitoring programs conducted by the Texas Parks & Wildlife Department Coastal Fisheries Program, the Texas Commission on Environmental Quality, and the Texas Department of State Health Services. Therefore, though point measurement data are available to serve as a guide for comparison, as with time-series data, relatively little data is available in the upper estuary. Figure 5 shows point measurement data extracted within an area adjacent to sites G1 – G4.

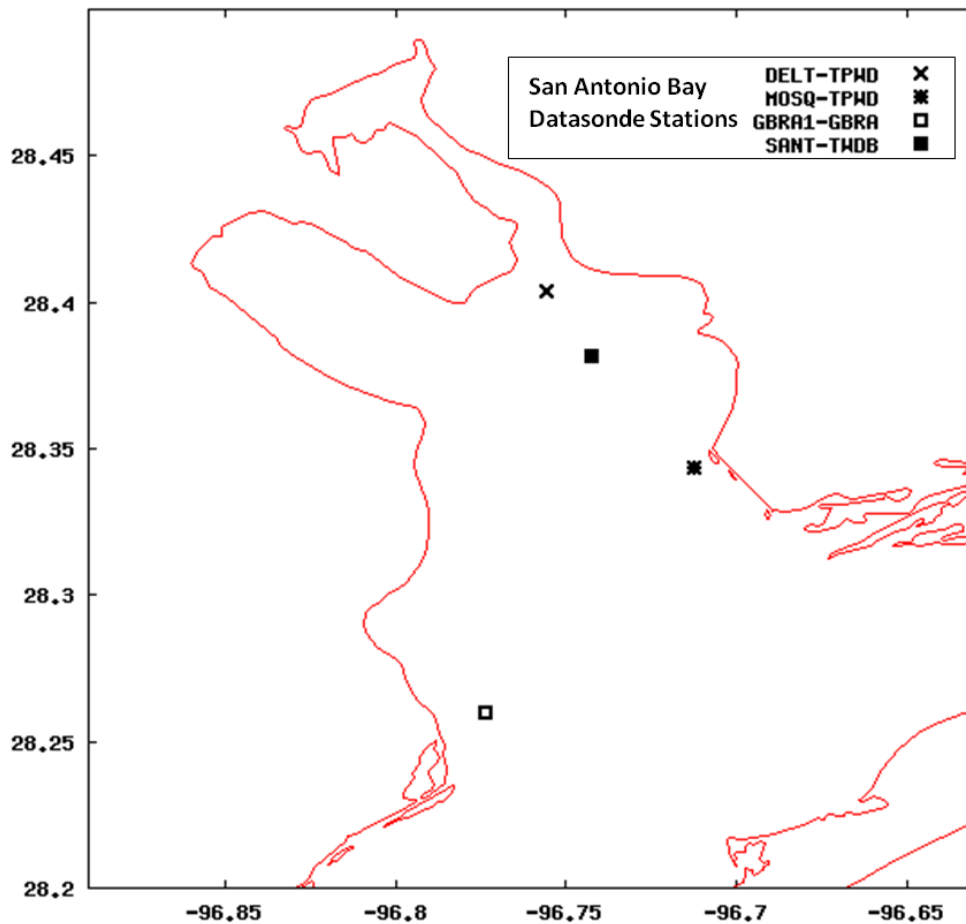


Figure 4. Datasonde station locations in San Antonio Bay which provide time-series salinity data. DELT (x), MOSQ (★), and SANT (■) stations are maintained by TPWD, though SANT is funded by the TWDB as part of the co-operative Datasonde Program. GBRA1 (□) is funded by the Guadalupe-Blanco River Authority and maintained by the Conrad Blucher Institute.

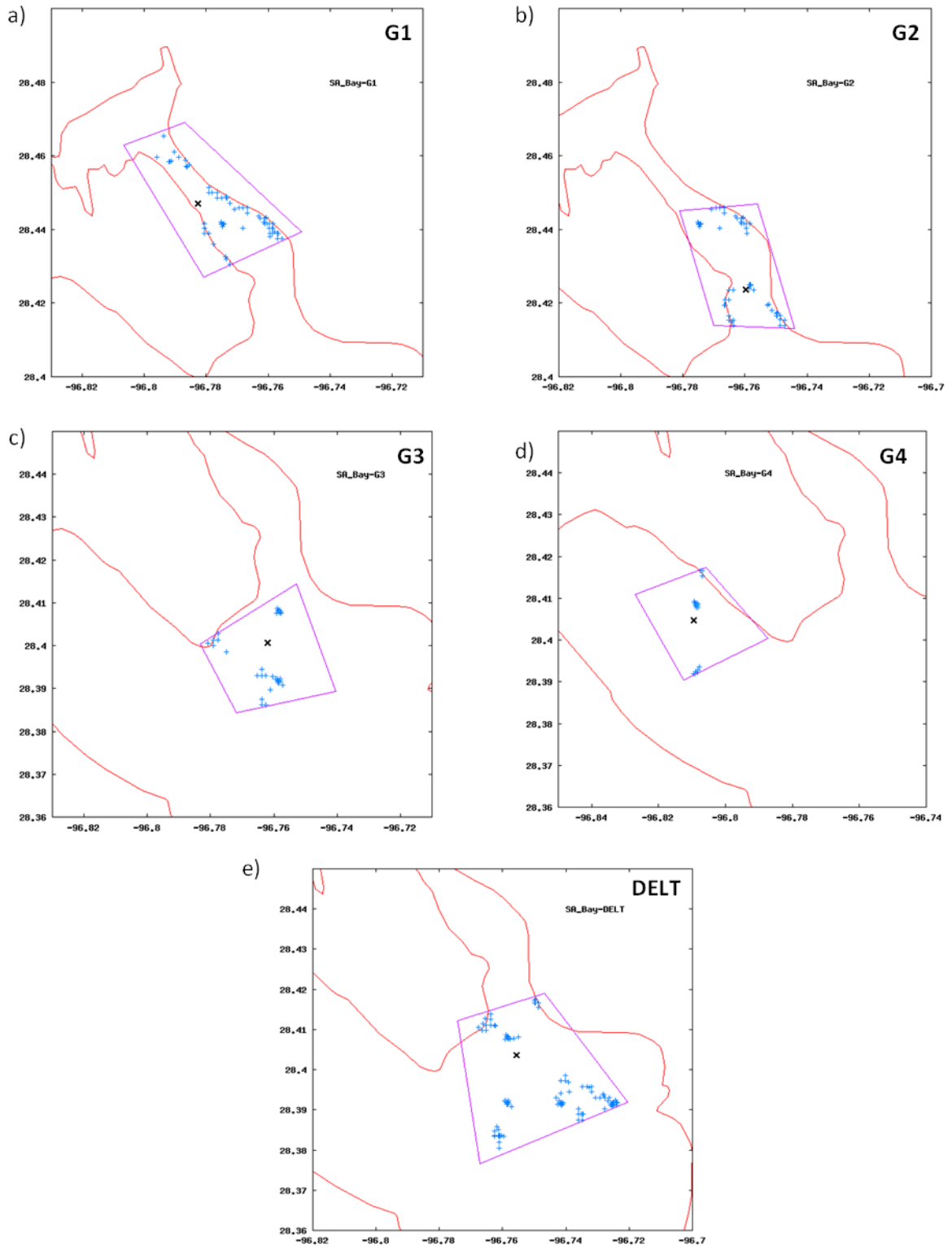


Figure 5. Sites of interest in the upper Guadalupe Estuary, (a) G1, (b) G2, (c) G3, (d) G4, (e) DELT. Each site (marked by *x*-symbol) is bounded by a polygon which defines the adjacent area from which point-measurement data (*blue + symbols*) were extracted for use in model validation. G1-G4 were locations of interest selected by the G-SA BBEST; DELT is a TPWD datasonde station in the upper estuary.

Table 2. Latitude and Longitude of the corners defining polygons surrounding sites G1 – G4 and DELT, from which point measurement salinity data was extracted for model validation.

	Polygon-G1		Polygon-G2	
	Latitude	Longitude	Latitude	Longitude
upper-left	28.462876	-96.806579	28.445000	-96.781000
upper-right	28.469113	-96.786847	28.447000	-96.756000
lower-left	28.427126	-96.780861	28.414000	-96.770000
lower-right	28.439266	-96.749075	28.413100	-96.744000
	Polygon-G3		Polygon-G4	
	Latitude	Longitude	Latitude	Longitude
upper-left	28.400409	-96.783165	28.410987	-96.827121
upper-right	28.414317	-96.752783	28.417414	-96.805848
lower-left	28.384345	-96.771797	28.390434	-96.812479
lower-right	28.389283	-96.740517	28.400318	-96.787223
	Polygon - DELT			
	Latitude	Longitude		
upper-left	28.412245	-96.774214		
upper-right	28.419071	-96.746713		
lower-left	28.376528	-96.767059		
lower-right	28.391978	-96.720495		

Results

Comparison to Observed Salinity Data

Figures 6 to 13 show that the TxBLEND model captures major salinity trends in the system reasonably, but higher frequency fluctuations are more difficult to simulate. The model also performs better at mid and lower bay locations than in the upper estuary. Summary statistics, comparing simulated to observed salinities, are shown in Table 3.

It is important to remember that relatively little to no data is available for model calibration in the upper estuary. Moreover, the upper estuary simulations of salinity are affected by the river boundary condition, which is set in relatively close proximity to the bay, and by the large size of the grid cells in this area. Improvements in model simulations of upper estuarine salinity conditions would require modifications to the TxBLEND model to move the river boundary further inland and reduce the size of the grid cells. While it is possible to make such modifications, these are not feasible in the time available to the BBEST. TxBLEND models of the major bays were not originally set up to focus on upper estuarine salinity dynamics and so less attention has been given to improving model performance in these bay locations. With increasing interest in modeling salinity in the upper estuarine zone and with increased access to data for these areas, TWDB can work to improve TxBLEND model performance in upper estuarine zones.

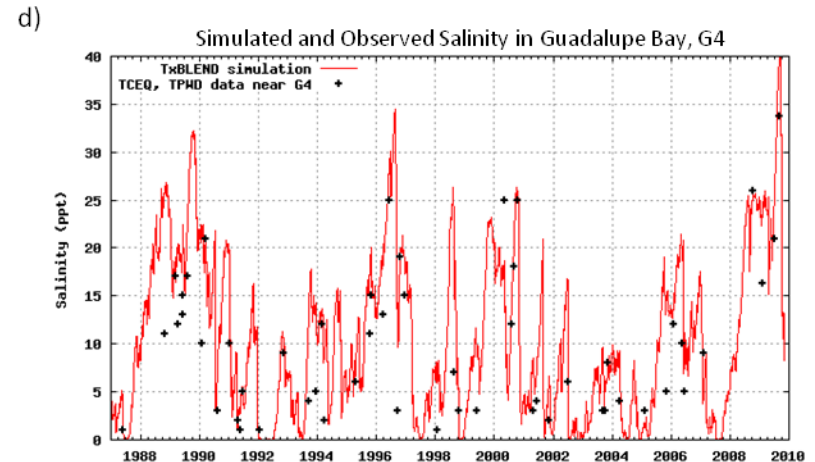
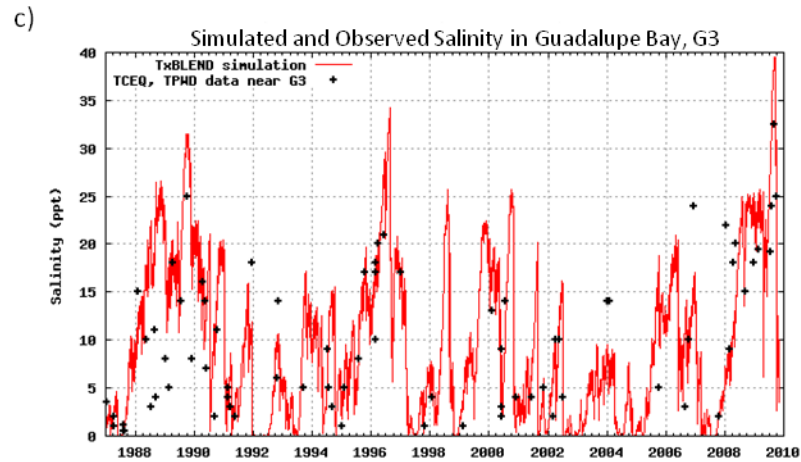
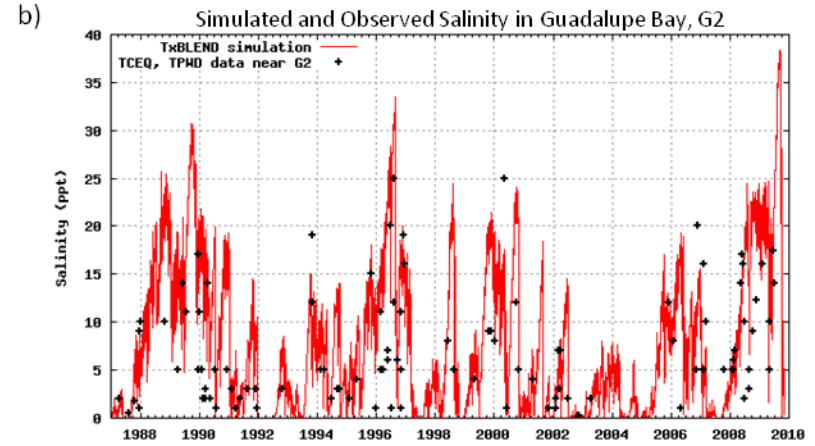
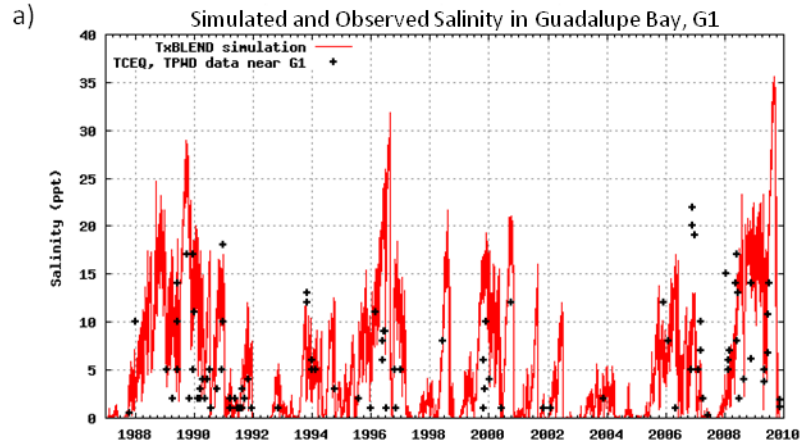


Figure 6. Simulated salinities (red) and observed point-measurement data (+ symbols) at sites (a) G1, (b) G2, (c) G3, and (d) G4 in the upper Guadalupe Estuary for the period 1987-2009.

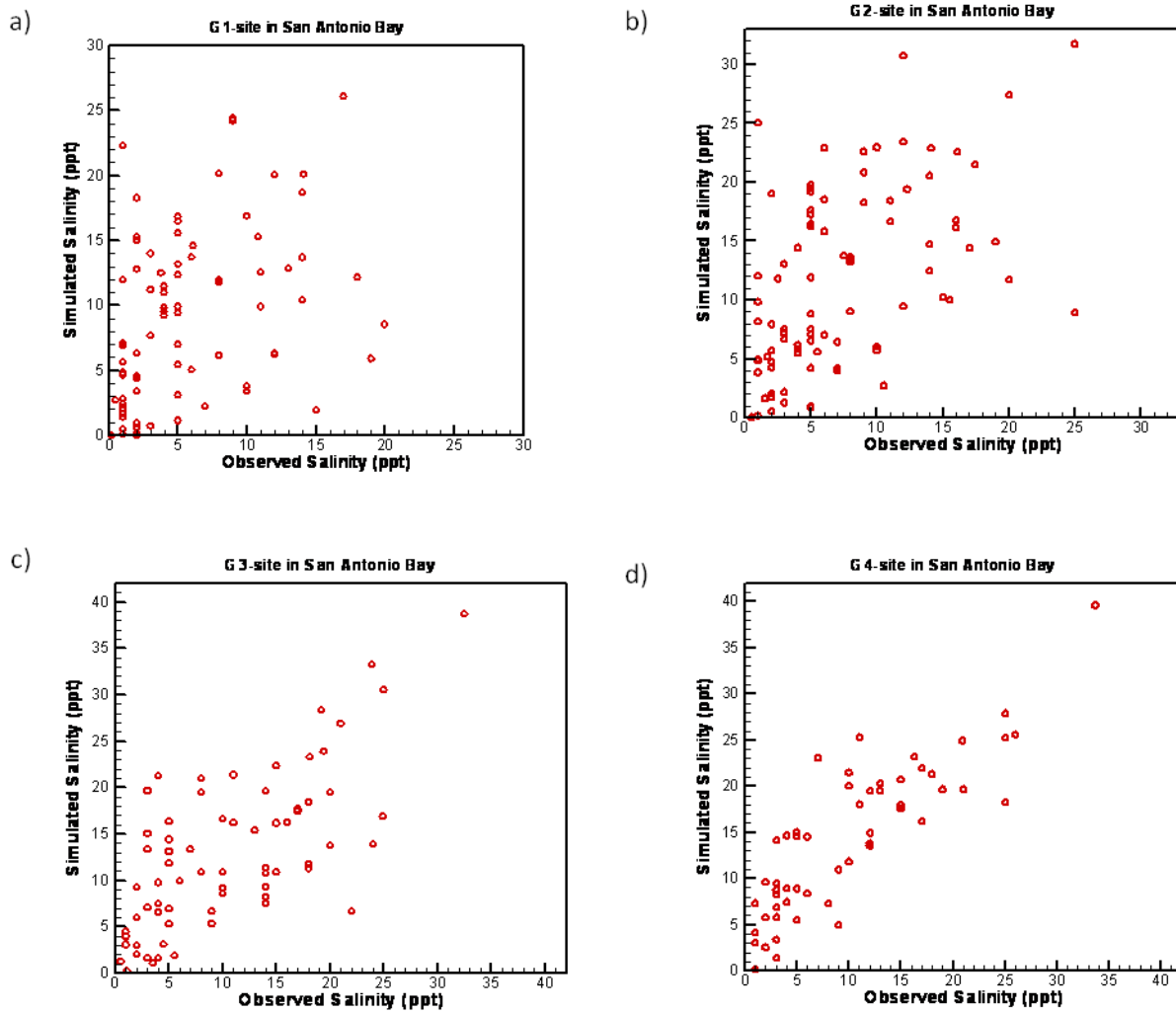


Figure 7. Scatter plot comparing simulated daily salinities to observed point measurements of salinity at sites (a) G1, (b) G2, (c) G3, and (d) G4 in the upper Guadalupe Estuary for the period 1987-2009.

Table 3. Statistics comparing simulated versus observed salinities during the period 1987-2009 at five locations in the upper Guadalupe Estuary. The quantity of observed data available for comparison varies among sites depending on availability.

Location	n	r^2	RMSE (ppt)	Nash-Sutcliffe	Average Salinity (ppt)	
					Simulated	Observed
G1	79	0.15	7.376	-1.168	9.22	5.85
G2	88	0.27	6.540	-0.916	11.67	7.36
G3	70	0.49	6.551	0.249	12.64	10.36
G4	54	0.72	6.072	0.395	14.32	10.11
DELT	203	0.47	6.329	0.385	12.19	11.43

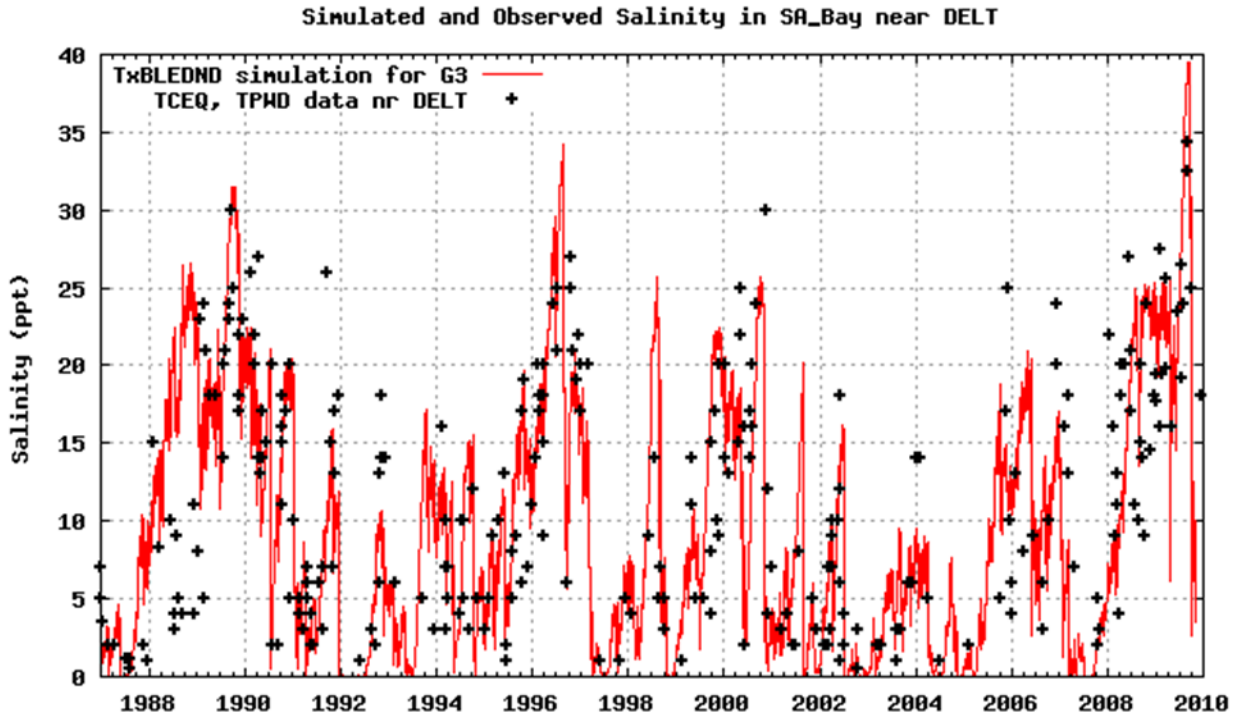


Figure 8. Simulated salinities (*red*) and observed point-measurement data (*+ symbols*) near the TPWD Datasonde site DELT in the upper Guadalupe Estuary for the period 1987-2009.

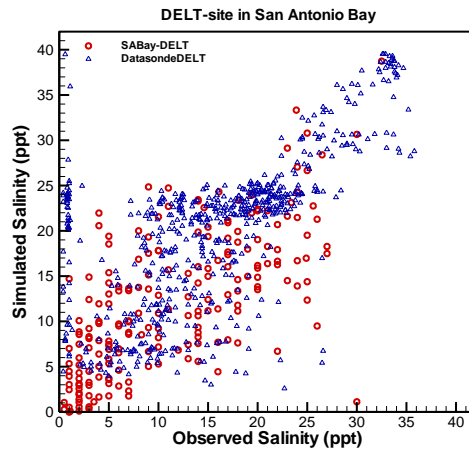


Figure 9. Scatter plot comparing simulated daily salinities (*red*) to observed point-measurements of salinity (*blue*) near the TPWD Datasonde site DELT the upper Guadalupe Estuary for the period 1987-2009.

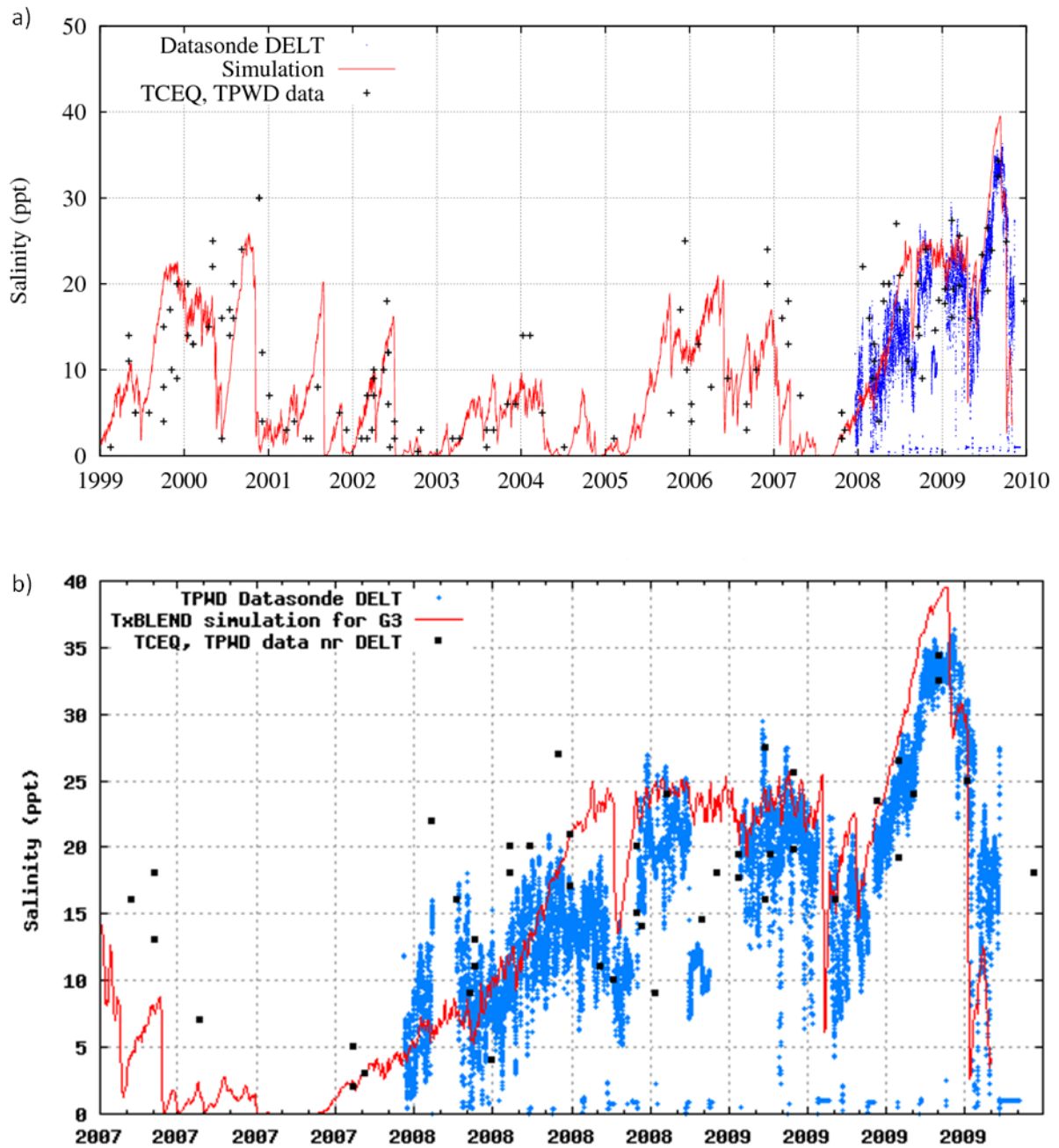


Figure 10. Observed (*blue, symbols +, ■*) versus simulated (*red*) salinities (at the G3 node) near the DELT site in San Antonio Bay for (a) 1999-2009 and (b) for 2007-2009.

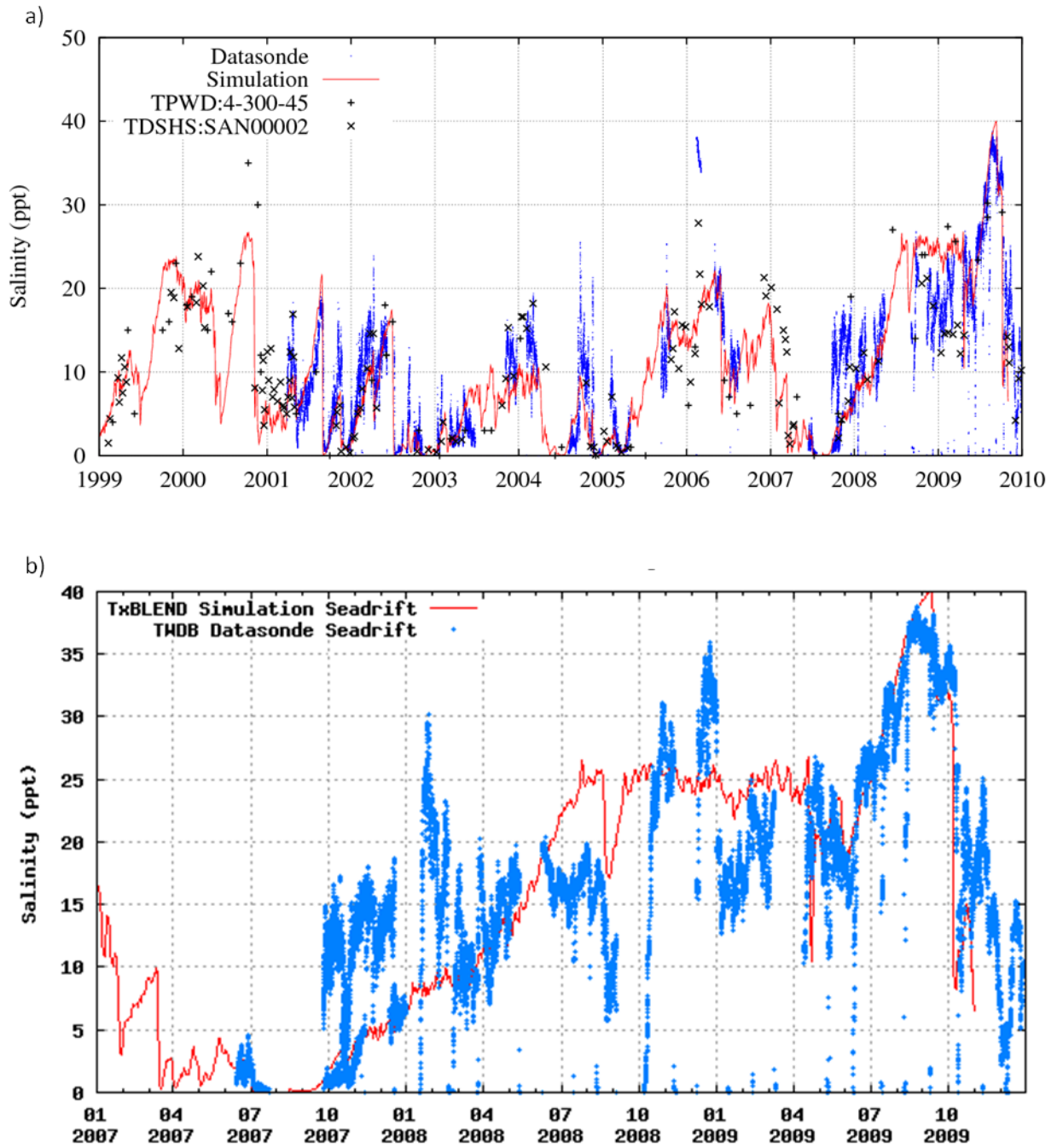


Figure 11. Observed (*blue* and *symbols +, x*) versus simulated (*red*) salinities at the Seadrift site in San Antonio Bay for (a) 1999-2009 and (b) for 2007-2009.

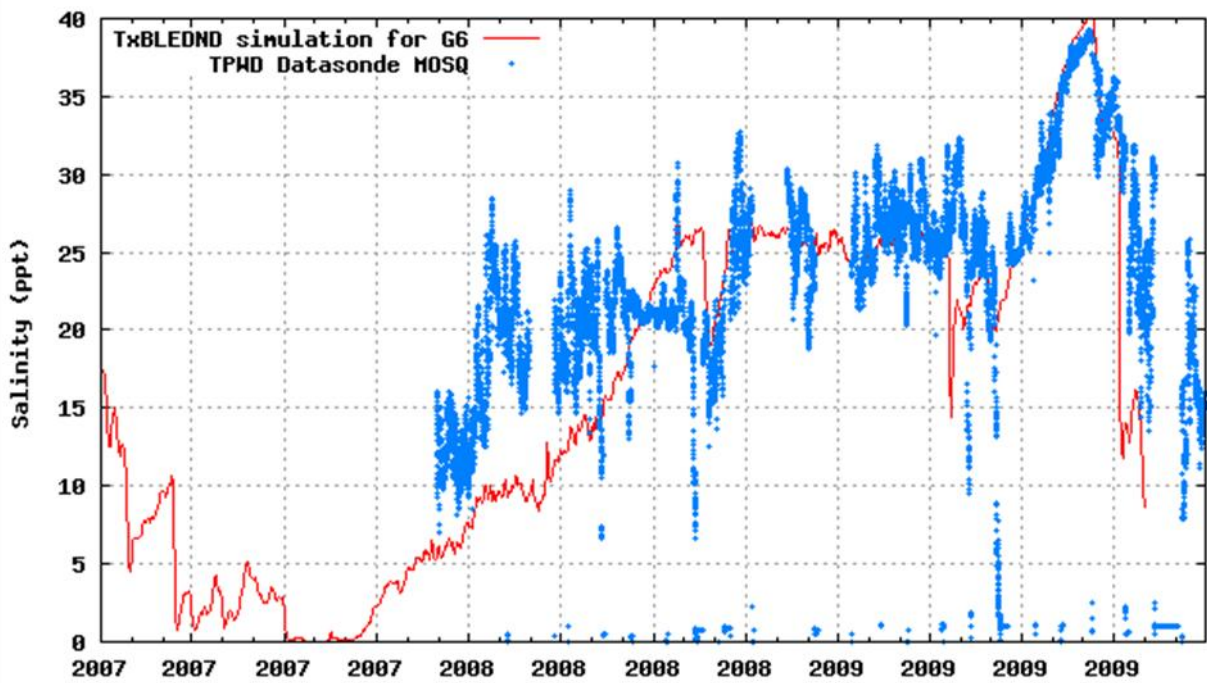


Figure 12. Observed (*blue*) versus simulated (*red*) salinities (near the G6 node) at the MOSQ site in San Antonio Bay for 2007-2009.

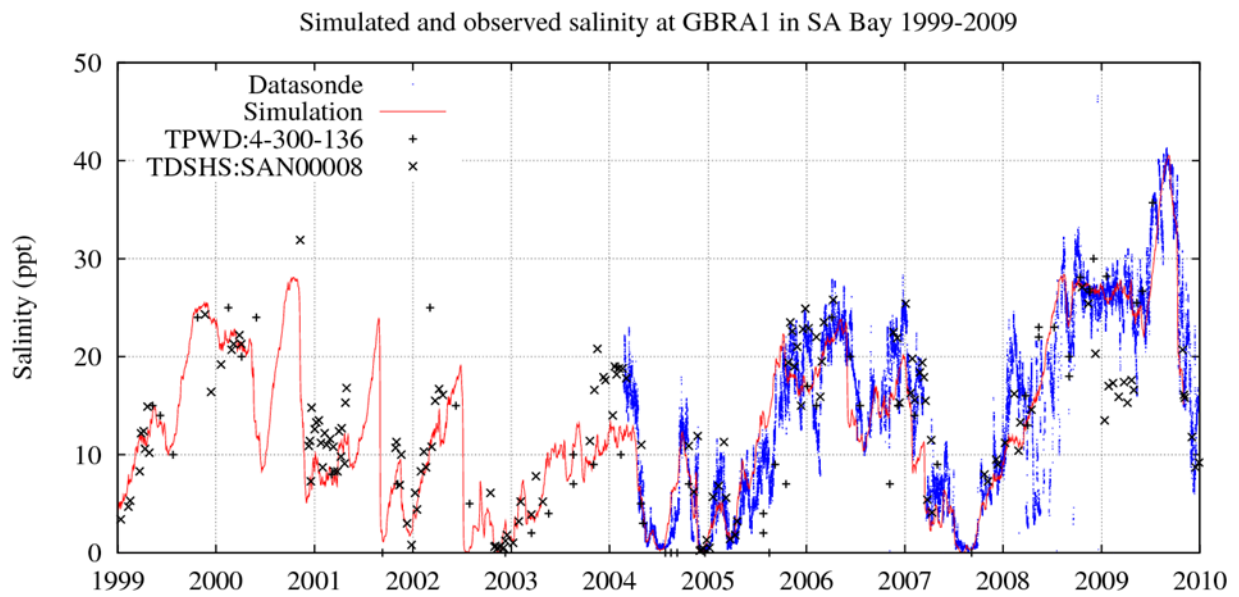


Figure 13. Observed (*blue and symbols x, +*) versus simulated (*red*) salinities at the GBRA1 site in San Antonio Bay for 1999-2009.

Literature Cited

TWDB. 2010a. *TxBLEND Model Calibration and Validation for the Guadalupe and Mission-Aransas Estuaries*. Texas Water Development Board, Austin, Texas. 45 pp.

TWDB. 2010b. *Coastal Hydrology for the Guadalupe Estuary: Updated Hydrology with Emphasis on Diversion and Return Flow Data for 2000-2009. November 2010*. Texas Water Development Board, Austin, Texas. 28 pp.

Appendix A: Comparisons of Different Estimates of Hydrology for the Guadalupe Estuary

As reported in this technical memo, the recent calibration and validation of the Guadalupe-Mission-Aransas TxBLEND model (TWDB 2010a) was based on a modified version of hydrology #TWDB201002 referred to as version Guad2009JM, whereby four watersheds (WS24607, WS24608, WS24603, and WS24606) were excluded in the calculation of ungaged flows used as inputs to the Guadalupe River inflow point in the model (see Table A-1 and Figure A-1). Because the TxBLEND validation and simulations presented in this technical memo are based on an alternative hydrology (#HDR201001) which include the four, previously excluded watersheds (version HDR), it is important to compare the effect of this variation on estimates of total combined inflows to the estuary.

Table A-1. Three estimates of combined inflows for the period 1987-2009 which were compiled as input for TxBLEND. Guad2009 and Guad2009JM are based on hydrology version #TWDB201002, where Guad2009JM was used in the calibration and validation of TxBLEND presented in *TxBLEND Model Calibration and Validation for the Guadalupe and Mission-Aransas Estuaries* (TWDB 2010a). HDR is based on the alternative hydrology version #HDR201001 and was used in simulations conducted for the Guadalupe-San Antonio Bay & Basin Expert Science Team and as the basis for results presented in this technical memo.

	Hydrology Version #TWDB201002	Hydrology Version #HDR201001
Includes all ungaged watersheds	Guad2009 (F2)	HDR (F1)
Exclude watersheds WS24607, WS24608, WS24603, and WS24606	Guad2009JM (F3)	n/a

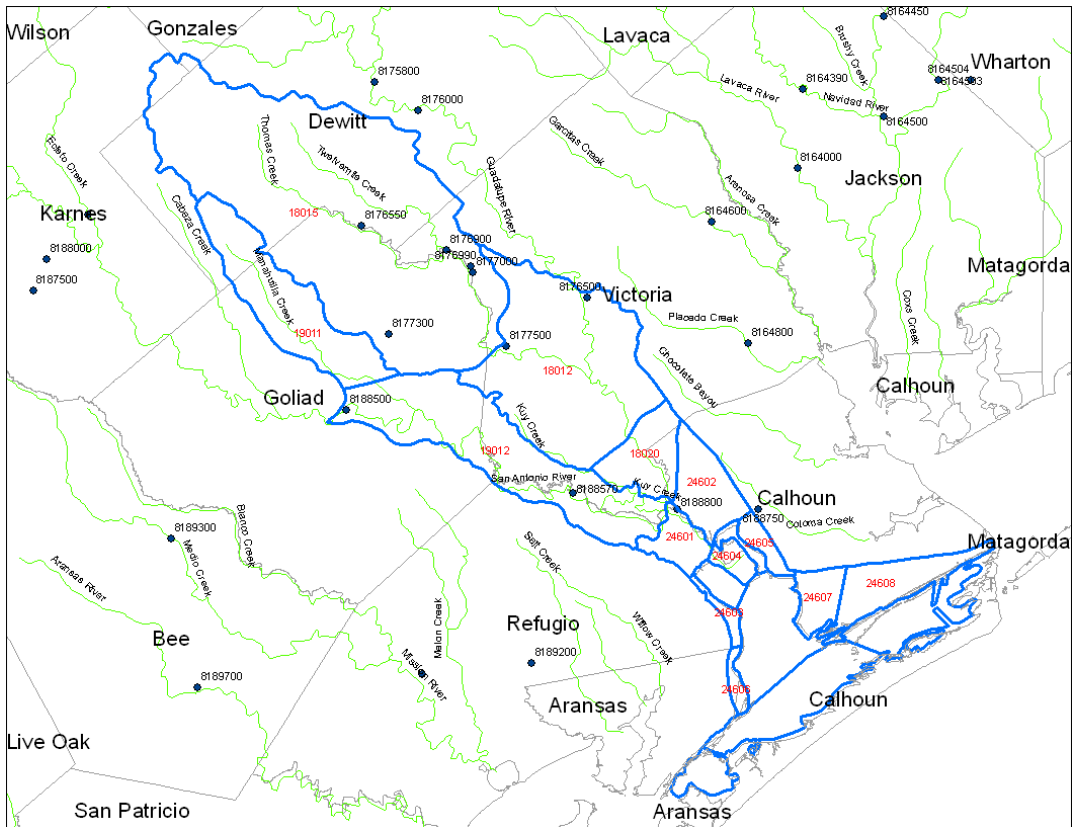
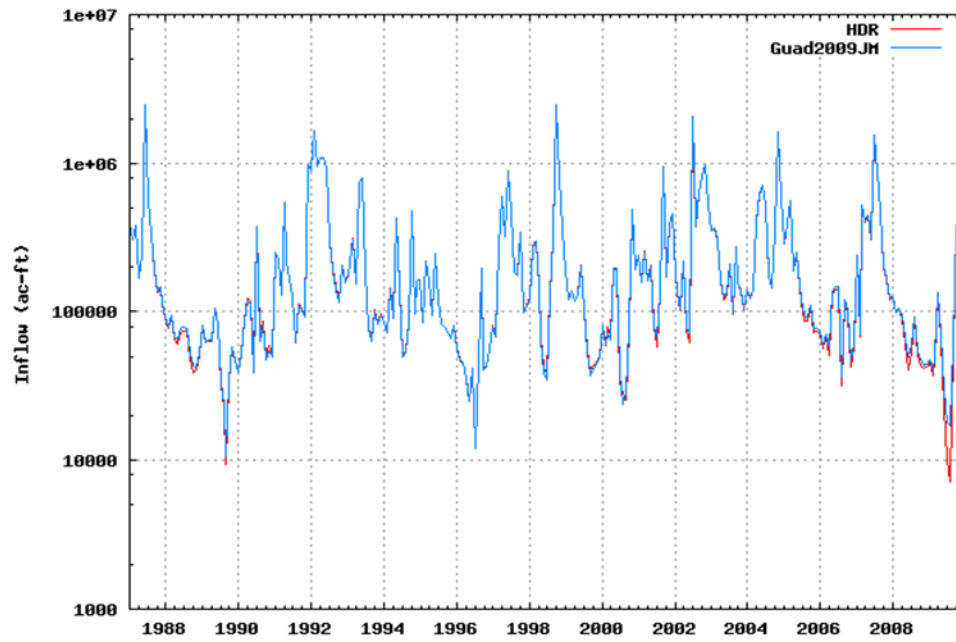


Figure A-1. Watershed delineation in the Guadalupe and San Antonio River basins. Ungaged watersheds, WS24607, WS24608, WS24603, and WS24606, were excluded in earlier estimates of combined inflows (Version #TWDB201002) used as inputs to the Guadalupe River inflow point in the TxBLEND model (as reported in TWDB 2010a). However, hydrology estimates used in this technical memo (Version #HDR201001) included the four ungaged watersheds.

Comparison of Versions of Hydrology

Figure 3 (earlier in the memo and again in Figure A-2) shows the comparison of estimates of combined inflows to the Guadalupe Estuary for the modified hydrology version #TWDB201002 (Guad2009JM) and the alternative hydrology version #HDR201001. Shown here as well, is a comparison of the most recent official hydrology developed by the TWDB (#TWDB201004) to the alternative hydrology (#HDR201001). Although a separate technical memo explains the development of coastal hydrology estimates in greater detail (TWDB 2010b), a comparison plot is shown here for informational purposes.

a)



b)

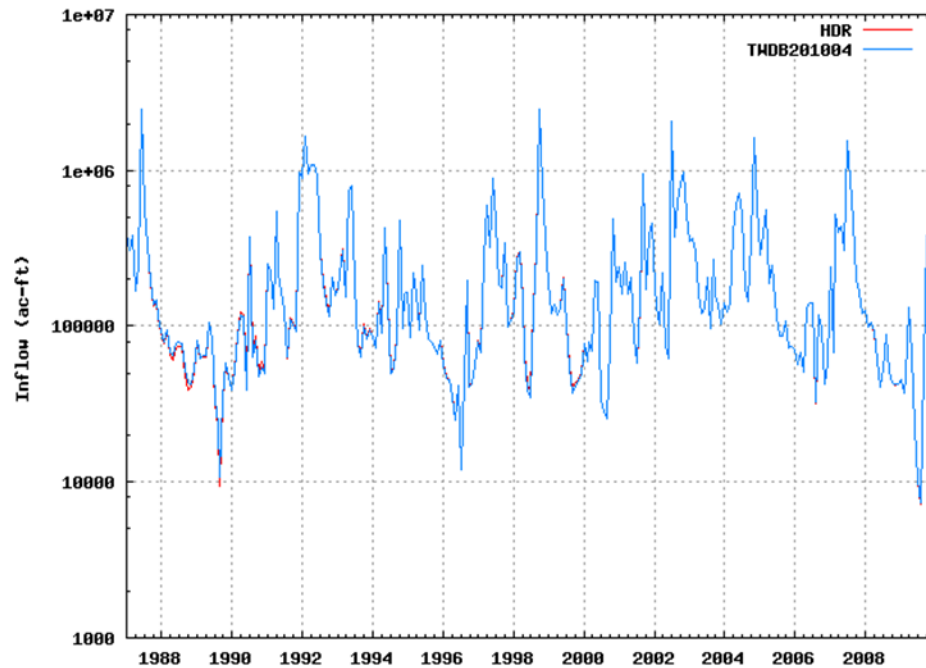


Figure A-2. (a) Same as Figure 3, a comparison of estimates of combined inflows to the Guadalupe Estuary for the modified hydrology version #TWDB201002 (Guad2009JM, *blue*; used to calibrate TxBLEND) and the alternative hydrology version #HDR201001 (*red*; used to generate salinity simulations for the Guadalupe-San Antonio BBEST as shown in this technical memo) and (b) a comparison of estimates for the most recent TWDB hydrology #TWDB201004 (*blue*) and the alternative hydrology version #HDR201001 (*red*); ordinate is a log scale.

The summer months of 2009 were a very dry period with river inflows greatly reduced as compared to other wetter years. During such conditions, it is interesting to evaluate the contribution of the four ungaged coastal watersheds, immediately adjacent to San Antonio Bay but located south of the mouth of the Guadalupe River, on total inflows to the estuary. Table A-2 shows the estimated combined inflows as calculated according to the above diagram. In most months, the four subwatersheds provide at least small contribution of inflows (greater than a 1,000 to several thousand acre-feet, as shown in Column F2-F3), with wetter months having an larger contribution and dry months, a lesser contribution down to a few hundred acre-feet or less.

The differences shown in Column F3-F1 however, are caused not only by the difference in the four watersheds but also by the recent updates to the hydrology (version #HDR201001) where net diversions, such as in 2009, reduced estimated inflows to the estuary (Column F1) – in comparison to the older version #TWDB201002 of hydrology (Column F2).

Table A-2. Three estimates of combined inflows used as input to the Guadalupe River inflow point in TxBLEND inflows and their differences (ac-ft). Column F1 shows the alternative hydrology version #HDR201001 (HDR). Columns F2 and F3 show two estimates of TWDB hydrology based on version #TWDB201002, where Guad2009 (F2) includes all watersheds and Guad2009JM (F3) excludes four ungaged watersheds (WS24607, WS24608, WS24603, and WS24606). Column F3-F1 shows the difference between the TWDB201002 hydrology with four ungaged watersheds removed (used as the input for the initial calibration and validation of TxBLEND, as presented in TWDB2010a) and the HDR201001 hydrology (used as input for TxBLEND simulations for the Guadalupe-San Antonio Bay & Basin Expert Science Team). Column F2-F3 shows the effect of excluding the four ungaged watersheds for the TWDB201002 estimate of hydrology. Column F2-F1 shows the difference between the TWDB201002 inflows and HDR201001 inflows (used as input for TxBLEND simulations for the Guadalupe-San Antonio Bay & Basin Expert Science Team).

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR F1	Guad2009 F2	Guad2009JM F3	F3-F1	F2-F3	F2-F1
1987	1	386125	387466	384099	-2026	3367	1341
1987	2	303864	305241	296233	-7631	9008	1377
1987	3	382803	385501	384818	2015	683	2698
1987	4	168523	169578	169488	965	90	1055
1987	5	239175	240109	238604	-571	1505	934
1987	6	2478048	2478391	2472011	-6037	6380	343
1987	7	556614	557545	550864	-5750	6681	931
1987	8	334657	335709	333224	-1433	2485	1052
1987	9	189241	192357	191531	2290	826	3116
1987	10	136040	137906	136681	641	1225	1866
1987	11	144715	145920	144420	-295	1500	1205
1987	12	113416	116398	116322	2906	76	2982
1988	1	91399	93031	92812	1413	219	1632
1988	2	77714	79246	79210	1496	36	1532
1988	3	93862	95473	95445	1583	28	1611
1988	4	64825	68395	68296	3471	99	3570
1988	5	60513	64573	64037	3524	536	4060

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR	Guad2009	Guad2009JM	F3-F1	F2-F3	F2-F1
		F1	F2	F3			
1988	6	71968	77248	76612	4644	636	5280
1988	7	74287	78942	77637	3350	1305	4655
1988	8	73425	77081	76863	3438	218	3656
1988	9	49095	53530	51232	2137	2298	4435
1988	10	38803	43824	43465	4662	359	5021
1988	11	40281	42775	42755	2474	20	2494
1988	12	51011	53241	53241	2230	0	2230
1989	1	79011	80345	75410	-3601	4935	1334
1989	2	61486	62744	62492	1006	252	1258
1989	3	63619	65045	65003	1384	42	1426
1989	4	63770	65092	65058	1288	34	1322
1989	5	105339	106741	106737	1398	4	1402
1989	6	82012	83332	74825	-7187	8507	1320
1989	7	31787	33174	29589	-2198	3585	1387
1989	8	22852	24119	20788	-2064	3331	1267
1989	9	9427	10662	10537	1110	125	1235
1989	10	33546	34823	32374	-1172	2449	1277
1989	11	57164	58544	55269	-1895	3275	1380
1989	12	46123	47421	47265	1142	156	1298
1990	1	39343	39073	38903	-440	170	-270
1990	2	52568	51986	49413	-3155	2573	-582
1990	3	87538	87355	82607	-4931	4748	-183
1990	4	122365	118101	117116	-5249	985	-4264
1990	5	118135	114919	112805	-5330	2114	-3216
1990	6	43844	38953	38874	-4970	79	-4891
1990	7	376457	371624	349120	-27337	22504	-4833
1990	8	69043	63993	63550	-5493	443	-5050
1990	9	86279	81333	80500	-5779	833	-4946
1990	10	50035	47092	47032	-3003	60	-2943
1990	11	59452	54320	54160	-5292	160	-5132
1990	12	51318	50130	50028	-1290	102	-1188
1991	1	249244	248748	246140	-3104	2608	-496
1991	2	225835	225108	224169	-1666	939	-727
1991	3	129777	128821	126049	-3728	2772	-956
1991	4	549542	545196	536098	-13444	9098	-4346
1991	5	215433	214370	211083	-4350	3287	-1063
1991	6	163766	164305	150604	-13162	13701	539
1991	7	124955	127340	126488	1533	852	2385
1991	8	62126	62844	60029	-2097	2815	718
1991	9	112124	111561	100300	-11824	11261	-563
1991	10	105092	102644	88915	-16177	13729	-2448

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR	Guad2009	Guad2009JM	F3-F1	F2-F3	F2-F1
		F1	F2	F3			
1991	11	94157	93113	84442	-9715	8671	-1044
1991	12	983133	981800	971010	-12123	10790	-1333
1992	1	895389	894310	884956	-10433	9354	-1079
1992	2	1665760	1665040	1645876	-19884	19164	-720
1992	3	958647	957048	946063	-12584	10985	-1599
1992	4	1084508	1082533	1075742	-8766	6791	-1975
1992	5	1077221	1075119	1062353	-14868	12766	-2102
1992	6	910638	909109	902067	-8571	7042	-1529
1992	7	302336	299987	295974	-6362	4013	-2349
1992	8	192959	190104	186493	-6466	3611	-2855
1992	9	146642	141122	139478	-7164	1644	-5520
1992	10	118173	116090	114725	-3448	1365	-2083
1992	11	207943	207020	197258	-10685	9762	-923
1992	12	160629	158430	157551	-3078	879	-2199
1993	1	176271	175060	173943	-2328	1117	-1211
1993	2	265213	264047	241679	-23534	22368	-1166
1993	3	311478	309002	294981	-16497	14021	-2476
1993	4	155088	153866	152276	-2812	1590	-1222
1993	5	724903	720909	713360	-11543	7549	-3994
1993	6	804909	800986	788767	-16142	12219	-3923
1993	7	185719	183799	183562	-2157	237	-1920
1993	8	76921	75090	75005	-1916	85	-1831
1993	9	64781	63043	62471	-2310	572	-1738
1993	10	102317	98750	97462	-4855	1288	-3567
1993	11	84489	82747	81981	-2508	766	-1742
1993	12	96830	94669	91083	-5747	3586	-2161
1994	1	85011	83957	82449	-2562	1508	-1054
1994	2	72748	71767	71644	-1104	123	-981
1994	3	144015	142588	140952	-3063	1636	-1427
1994	4	92431	91381	90781	-1650	600	-1050
1994	5	426233	425055	423845	-2388	1210	-1178
1994	6	143230	141735	138484	-4746	3251	-1495
1994	7	51277	49885	49768	-1509	117	-1392
1994	8	54590	53060	51027	-3563	2033	-1530
1994	9	85394	84374	80387	-5007	3987	-1020
1994	10	479108	477923	472144	-6964	5779	-1185
1994	11	96791	95679	95496	-1295	183	-1112
1994	12	162444	161976	158643	-3801	3333	-468
1995	1	164253	163820	163069	-1184	751	-433
1995	2	84090	83786	83525	-565	261	-304
1995	3	218348	217792	215728	-2620	2064	-556

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR	Guad2009	Guad2009JM	F3-F1	F2-F3	F2-F1
		F1	F2	F3			
1995	4	162649	162200	160446	-2203	1754	-449
1995	5	95865	95410	92945	-2920	2465	-455
1995	6	246229	245931	243578	-2651	2353	-298
1995	7	117931	117773	117240	-691	533	-158
1995	8	82152	82028	81896	-256	132	-124
1995	9	79719	79660	79634	-85	26	-59
1995	10	73289	72977	67084	-6205	5893	-312
1995	11	66963	66425	64609	-2354	1816	-538
1995	12	81533	80262	74621	-6912	5641	-1271
1996	1	56432	55967	55934	-498	33	-465
1996	2	47620	47013	47013	-607	0	-607
1996	3	45720	45102	45102	-618	0	-618
1996	4	35834	34600	34290	-1544	310	-1234
1996	5	25096	24787	24787	-309	0	-309
1996	6	41914	41823	41575	-339	248	-91
1996	7	11938	11938	11938	0	0	0
1996	8	45878	45572	40689	-5189	4883	-306
1996	9	197404	197286	187945	-9459	9341	-118
1996	10	41551	41022	35806	-5745	5216	-529
1996	11	43292	42776	40435	-2857	2341	-516
1996	12	56086	55404	54982	-1104	422	-682
1997	1	81042	79061	76853	-4189	2208	-1981
1997	2	69336	67860	67580	-1756	280	-1476
1997	3	269511	267224	246669	-22842	20555	-2287
1997	4	602945	600997	591842	-11103	9155	-1948
1997	5	321482	319596	311943	-9539	7653	-1886
1997	6	887835	886003	885002	-2833	1001	-1832
1997	7	469033	467268	467168	-1865	100	-1765
1997	8	183924	182103	181683	-2241	420	-1821
1997	9	178084	176011	161937	-16147	14074	-2073
1997	10	341760	339404	312961	-28799	26443	-2356
1997	11	99898	98405	94019	-5879	4386	-1493
1997	12	109592	107947	107601	-1991	346	-1645
1998	1	125806	122206	122085	-3721	121	-3600
1998	2	272351	269778	268574	-3777	1204	-2573
1998	3	301001	298246	297724	-3277	522	-2755
1998	4	147862	143819	143751	-4111	68	-4043
1998	5	67404	64274	64268	-3136	6	-3130
1998	6	42855	38624	38624	-4231	0	-4231
1998	7	38496	35017	34686	-3810	331	-3479
1998	8	129454	126606	124171	-5283	2435	-2848

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR	Guad2009	Guad2009JM	F3-F1	F2-F3	F2-F1
		F1	F2	F3			
1998	9	311376	308473	302456	-8920	6017	-2903
1998	10	2477172	2474090	2461151	-16021	12939	-3082
1998	11	794989	792446	781665	-13324	10781	-2543
1998	12	361229	359027	358712	-2517	315	-2202
1999	1	188278	186853	186309	-1969	544	-1425
1999	2	123179	121772	121175	-2004	597	-1407
1999	3	138794	137217	136414	-2380	803	-1577
1999	4	119172	117284	116998	-2174	286	-1888
1999	5	131724	129762	129737	-1987	25	-1962
1999	6	205012	202971	202951	-2061	20	-2041
1999	7	104317	102273	101668	-2649	605	-2044
1999	8	55364	53349	53343	-2021	6	-2015
1999	9	39806	37368	37338	-2468	30	-2438
1999	10	43548	41503	41425	-2123	78	-2045
1999	11	45808	44283	44283	-1525	0	-1525
1999	12	50163	48701	48699	-1464	2	-1462
2000	1	77582	81461	80566	2984	895	3879
2000	2	59269	60049	60029	760	20	780
2000	3	79117	70931	68250	-10867	2681	-8186
2000	4	69693	65483	64100	-5593	1383	-4210
2000	5	197315	198087	177352	-19963	20735	772
2000	6	192137	196907	181688	-10449	15219	4770
2000	7	34358	38542	38361	4003	181	4184
2000	8	27718	24125	23028	-4690	1097	-3593
2000	9	25310	28402	28103	2793	299	3092
2000	10	74332	79229	79088	4756	141	4897
2000	11	490849	494027	492277	1428	1750	3178
2000	12	194159	193444	192526	-1633	918	-715
2001	1	239358	239854	235377	-3981	4477	496
2001	2	160451	159020	158944	-1507	76	-1431
2001	3	255049	247920	247760	-7289	160	-7129
2001	4	160278	161656	161644	1366	12	1378
2001	5	207345	202938	200236	-7109	2702	-4407
2001	6	82195	76043	75282	-6913	761	-6152
2001	7	58472	67088	66562	8090	526	8616
2001	8	139308	133762	130876	-8432	2886	-5546
2001	9	941876	943019	938800	-3076	4219	1143
2001	10	174032	174181	172859	-1173	1322	149
2001	11	389439	389257	380960	-8479	8297	-182
2001	12	454318	454220	453646	-672	574	-98
2002	1	173373	174373	172725	-648	1648	1000

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR	Guad2009	Guad2009JM	F3-F1	F2-F3	F2-F1
		F1	F2	F3			
2002	2	114082	114393	114320	238	73	311
2002	3	103866	105634	105604	1738	30	1768
2002	4	217421	220693	220526	3105	167	3272
2002	5	73349	79395	79171	5822	224	6046
2002	6	62494	71586	69215	6721	2371	9092
2002	7	2073028	2077257	2070884	-2144	6373	4229
2002	8	378647	384848	381549	2902	3299	6201
2002	9	628824	633420	616013	-12811	17407	4596
2002	10	819666	821562	788666	-31000	32896	1896
2002	11	976250	977130	944366	-31884	32764	880
2002	12	524025	524928	519918	-4107	5010	903
2003	1	347144	347607	343715	-3429	3892	463
2003	2	366763	367455	365430	-1333	2025	692
2003	3	302931	304792	302595	-336	2197	1861
2003	4	160545	162161	162077	1532	84	1616
2003	5	121196	126071	126047	4851	24	4875
2003	6	128955	134078	130615	1660	3463	5123
2003	7	205260	211238	193290	-11970	17948	5978
2003	8	95782	98948	97776	1994	1172	3166
2003	9	267759	272805	253327	-14432	19478	5046
2003	10	155958	158315	154611	-1347	3704	2357
2003	11	138830	139886	139318	488	568	1056
2003	12	103158	105797	105506	2348	291	2639
2004	1	140815	142488	140672	-143	1816	1673
2004	2	124032	125023	124685	653	338	991
2004	3	141055	142233	142099	1044	134	1178
2004	4	398166	399453	397594	-572	1859	1287
2004	5	616107	618840	585251	-30856	33589	2733
2004	6	710348	715367	696651	-13697	18716	5019
2004	7	519516	525495	520102	586	5393	5979
2004	8	172529	177213	176920	4391	293	4684
2004	9	143534	144282	144076	542	206	748
2004	10	349354	350753	338362	-10992	12391	1399
2004	11	1605954	1606445	1596123	-9831	10322	491
2004	12	580275	581117	580724	449	393	842
2005	1	289098	292051	291679	2581	372	2953
2005	2	390430	391828	390348	-82	1480	1398
2005	3	560102	561257	552699	-7403	8558	1155
2005	4	187568	188254	188111	543	143	686
2005	5	248250	250115	248543	293	1572	1865
2005	6	145977	150655	149873	3896	782	4678

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR	Guad2009	Guad2009JM	F3-F1	F2-F3	F2-F1
		F1	F2	F3			
2005	7	113309	120349	115967	2658	4382	7040
2005	8	86288	94418	93882	7594	536	8130
2005	9	87263	91736	89354	2091	2382	4473
2005	10	107689	109339	95910	-11779	13429	1650
2005	11	72298	77036	73592	1294	3444	4738
2005	12	74660	77693	77098	2438	595	3033
2006	1	71116	73933	73754	2638	179	2817
2006	2	56322	59451	59347	3025	104	3129
2006	3	68136	71640	71228	3092	412	3504
2006	4	50360	57047	57021	6661	26	6687
2006	5	131108	139227	131478	370	7749	8119
2006	6	140957	148133	125446	-15511	22687	7176
2006	7	139754	147630	102598	-37156	45032	7876
2006	8	32211	36211	32654	443	3557	4000
2006	9	116905	121212	111339	-5566	9873	4307
2006	10	97088	100376	95027	-2061	5349	3288
2006	11	42922	46100	45606	2684	494	3178
2006	12	58148	61736	58960	812	2776	3588
2007	1	238930	241662	212226	-26704	29436	2732
2007	2	68403	70734	69264	861	1470	2331
2007	3	524539	527488	519908	-4631	7580	2949
2007	4	403506	405434	399871	-3635	5563	1928
2007	5	441071	445848	442050	979	3798	4777
2007	6	309771	316764	311629	1858	5135	6993
2007	7	1547385	1551112	1484094	-63291	67018	3727
2007	8	873923	878112	859806	-14117	18306	4189
2007	9	469963	472505	468715	-1248	3790	2542
2007	10	201847	205413	203881	2034	1532	3566
2007	11	163793	167729	165383	1590	2346	3936
2007	12	121272	124466	123993	2721	473	3194
2008	1	126100	127218	120683	-5417	6535	1118
2008	2	98489	99474	97530	-959	1944	985
2008	3	105628	106005	105347	-281	658	377
2008	4	91480	94237	92699	1219	1538	2757
2008	5	60532	66920	66826	6294	94	6388
2008	6	40816	49476	48019	7203	1457	8660
2008	7	53067	60735	60341	7274	394	7668
2008	8	88259	92296	83976	-4283	8320	4037
2008	9	50882	54310	53985	3103	325	3428
2008	10	43440	47969	47274	3834	695	4529
2008	11	41961	43723	43477	1516	246	1762

Year	Month	Version #HDR201001	Version #TWDB201002		Difference Between Inflow Estimates		
		HDR	Guad2009	Guad2009JM	F3-F1	F2-F3	F2-F1
		F1	F2	F3			
2008	12	42752	44831	44782	2030	49	2079
2009	1	45707	47436	47430	1723	6	1729
2009	2	37346	39484	39484	2138	0	2138
2009	3	48004	50288	49979	1975	309	2284
2009	4	131360	133727	133514	2154	213	2367
2009	5	66216	71544	69175	2959	2369	5328
2009	6	22313	29674	29517	7204	157	7361
2009	7	10071	18094	18094	8023	0	8023
2009	8	7217	17135	17135	9918	0	9918
2009	9	55613	59345	56590	977	2755	3732
2009	10	382542	380134	368115	-14427	12019	-2408
2009	11	357298	359008	347346	-9952	11662	1710
2009	12	184719	183738	175534	-9185	8204	-981